Risk and Vulnerability Analysis of Large-Scale Technical Infrastructures

Electrical Distribution Systems

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Abstract

The thesis treats the subject of risk and vulnerability analysis of large-scale technical infrastructures. In particular the focus is on the development of methods for vulnerability analysis of electrical distribution systems. The methods and the concepts behind them should nevertheless also be seen as applicable to other technical infrastructures.

Robust and reliable technical infrastructures are a prerequisite for modern society. If they fail to deliver their services, severe consequences arise. Two major crises in Sweden regarding the supply of electricity have clearly showed the magnitude of the consequences on society and its dependency on a reliable electricity supply and the emergency response necessary to return to normal. Furthermore, most technical infrastructures depend on a reliable power supply for their proper functioning. The power supply in turn relies on some of these for its proper operation and control. There is a need for methods aimed at assessing the vulnerability of the interconnected infrastructures the society depends upon.

In the thesis two approaches, or methods, of assessing the vulnerability of technical infrastructures are presented: global vulnerability analysis and critical components. The applicability of the methods was tested by empirical studies of three electrical distribution systems in Sweden. The result from the global vulnerability analysis clearly shows that distribution systems are highly vulnerable to some type of perturbations. The results from the analysis of critical components show that the methods can be used for finding and ranking components that are critical for the system and that they render a very feasible way to test the system for *N-k* contingencies.

The design approach of the methods was to use a network model and a corresponding physical model of the electrical distribution system. The network model contains the topological information. The physical model describes the behavior of the network. Performance measures have been developed to describe the consequences of perturbation to the network. The studies indicate that these measures are relevant for describing vulnerability of an electrical distribution system and in finding its critical components. The design approach of the methods constitutes an important step towards vulnerability analysis of interdependent infrastructures.

The results from applying the methods can be useful for emergency mitigation and preparedness planning. The results can further be visualized in the form of geographical vulnerability maps. These maps can facilitate the discussions between persons working in different fields.